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XII. "On the Action of Bile upon Fats ; with Additional Observations on Excretine." By W. MARCET, M.D., F.R.S., Assistant Physician and Lecturer on Chemistry to the Westminster Hospital. Received June 10, 1858.

(Abstract.)

Having formerly observed and communicated to the Société de Biologie of Paris, that by heating a solution of neutral tribasic phosphate of soda ($2\text{NaO} \cdot \text{HO} \cdot \text{PO}_5$) mixed with animal fatty acids, an emulsion was obtained attended with the formation of a small quantity of soap, while no such action occurred if neutral fats were used instead of fatty acids, I was induced to inquire into the nature of the action of bile on neutral fats and fatty acids (sheep's bile being used), with the final object of throwing, if possible, some additional light on the digestion of fats. These investigations led to the following results :—

1. A mixture of bile and neutral fats (stearine, oleine and margarine), heated to a temperature above the fusing-point of the fat, undergoes no change, and no chemical action takes place.

2. A mixture of bile and fatty acids (stearic, oleic, and margaric acids), heated to a temperature above the fusing-point of the fatty acids, is transformed into a solution, a very few and minute globules only of fat remaining unacted upon from the presence of oleic acid. This solution becomes a perfect emulsion on cooling, and is attended with a chemical decomposition of the bile ; and further, if the emulsion of bile and fatty acids be filtered when quite cold, and the residue on the filter thoroughly washed with distilled water, the filtrate and washings mixed together again possess the property of forming an emulsion with another quantity of fatty acids, being also at the same time partly decomposed, although in the previous operation the bile appeared to have exhausted its power on the fatty acids. The filtrate and washings from this second operation again act upon a fresh quantity of fatty acids, and so on ; only in every subsequent operation the proportion of emulsion obtained appears to diminish, and the induced chemical decomposition to be lessened.

3. Pure oleic acid, when agitated with bile, cold or hot, produces no emulsion or chemical action whatever.

4. The stomach during digestion has the power of decomposing

the fats contained in the food into fatty acids, fats acquiring thereby the property of being acted upon chemically by the bile, and of being transformed into an emulsion.

The chemical action, or saponification, induced by the fatty acids under the above circumstances, was proved by the mixture acquiring a strong acid reaction; and it was further observed that the acid filtrate from the cold emulsion was not precipitated by hydrochloric acid, showing apparently that fatty acids exert on bile a chemical decomposition at least as extensive as hydrochloric acid. With the view of determining precisely the amount of soap formed, a method of analysis was adopted calculated to indicate the proportion of fatty acid remaining unacted upon by the bile: the difference between the fatty acids used and the result of the above operation was equal to the weight of the fatty acids saponified. It was found, in three analyses, that the mixture of bile and fatty acids being exposed for three hours (in Analysis II. for $3\frac{1}{2}$ hours) to the heat of an open water-bath, contained an amount of soap in which the proportion of fatty acids was 30·21 per cent., 20·5 per cent., 11·5 per cent. of that employed in the analysis. The filtrate from the emulsion in analysis No. II., mixed with the solution obtained by washing the emulsion with distilled water, was treated for three hours on the water-bath with a fresh quantity of fatty acids, which operation yielded a proportion of fatty acid saponified equal to 12·7 per cent. of that used in the analysis. Finally, the filtrate and washings obtained in this last group were mixed with another quantity of fatty acids, and exposed for three hours to the heat of the water-bath, in which case the proportion of fatty acid saponified was equal to 3·8 per cent. of that used in the analysis. The various operations had been attended with the formation of an emulsion.

In order to be certain that, after exposing a mixture of bile and fatty acids to the heat of a water-bath for three hours, the chemical action thus induced, was completely exhausted, two analyses were undertaken according to the process just mentioned, and with bile from the same gall-bladder; but in one operation the mixture was heated for three hours, and in the other for six hours: the proportion of fatty acid saponified was the same in both cases, showing that after three hours the bile had ceased to act on the fatty acids.

Having obtained the above results, an inquiry was next undertaken

respecting the state of the fats of food in the stomach during digestion. For this purpose the contents of the stomach of several dogs, fed with cooked meat and neutral sheep's fat, were examined at different stages of digestion; the acids of the stomach soluble in water were removed by protracted washings with distilled water, and the residue being treated with alcohol and ether, yielded solutions found to contain fatty acids. In some cases the contents of the stomach were first treated with alcohol, and the fatty matters thus obtained subsequently washed with distilled water, and finally again dissolved in alcohol and ether. These analyses constantly yielded fatty acids, which, when heated with fresh sheep's bile, were found to dissolve and produce an emulsion.

In order to determine whether the cooking of the meat with which the dogs had been fed had transformed any of the neutral fats into fatty acids, a sample of roast meat was mixed and washed with distilled water until the washings had completely lost their acid reaction; the meat was then mixed with alcohol and allowed to stand for more than a week. After that time the fluid was found to be perfectly neutral, showing that no fatty acids had been formed.

From these researches it appears that the presence of bile in the intestines is closely connected with the digestion of fats.

The results of recent investigations on excretine show that this substance exists on an average in the proportion of 0.460 grm. for one evacuation when the excretine is impure, and of 0.184 grm. when it is pure. From the careful examination of the fæces of a child one year old, I have ascertained that they invariably contained no excretine, but cholesterine; the proportion of the latter, purified by repeated crystallizations, being equal to 0.036 grm. in one evacuation, which number is, however, a very low estimate. Nothing in the food could account for this singular result. It is therefore most probable that excretine is only present in the evacuations of the full-grown or adult individual.

I have been most ably aided in these investigations by my assistant, Mr. Frederick Dupré, Ph.D.